No. 768,953. PATENTED AUG. 30, 1904.

L. T. ROBINSON.

RECORDING APPARATUS FOR ELECTRIC WAVES.

APPLICATION FILED NOV. 11, 1901.

NO MODEL. 2 SHEETS—SHEET 1.

Fig.1.

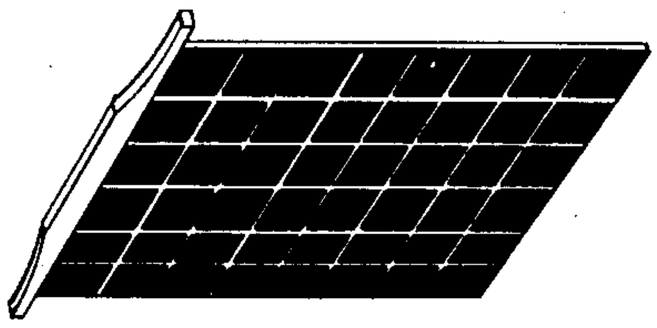


Fig.4.

Fig.2.

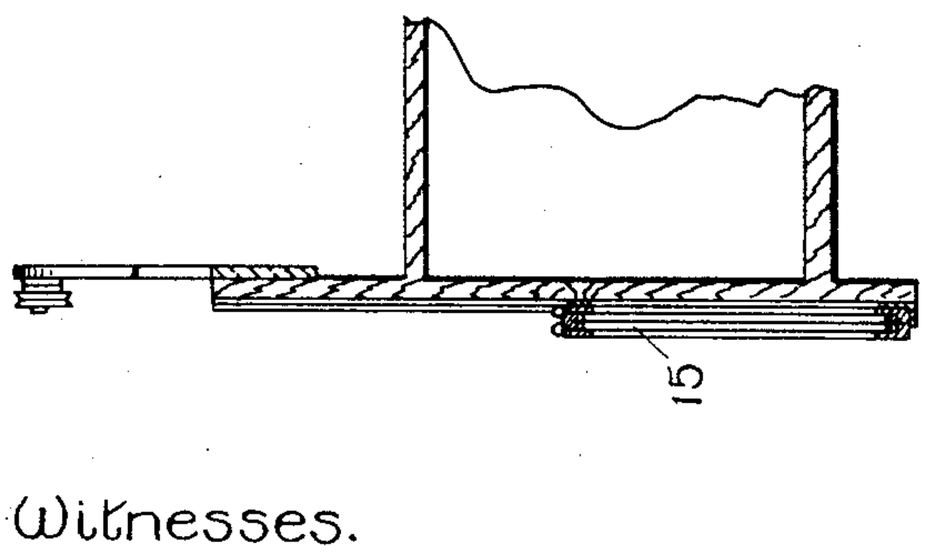
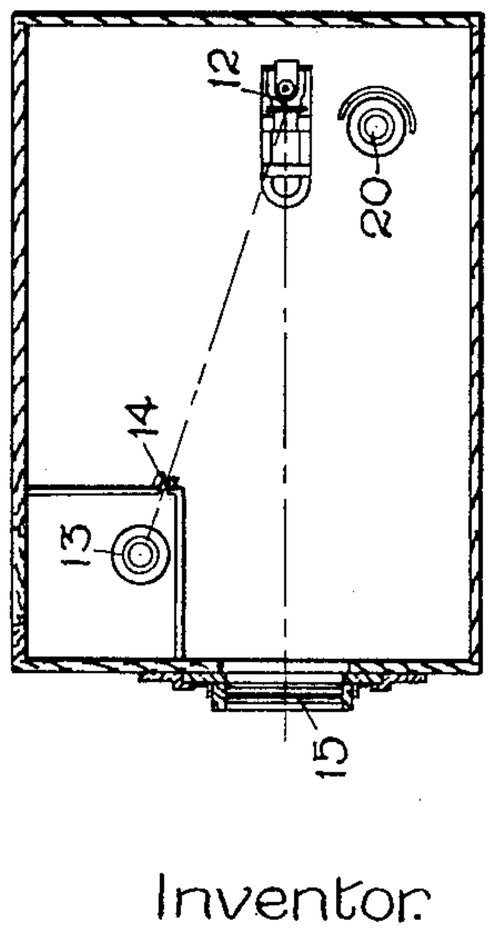


Fig.3.



Witnesses.
Ewing P. Gunnell.
Benjamin B. Hull.

Inventor:
Lewis T. Robinson.
by Albert G. Davis
Atty.

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APPLICATION FILED NOV. 11, 1901.

NO MODEL. 2 SHEETS—SHEET 2.

Fig.5.

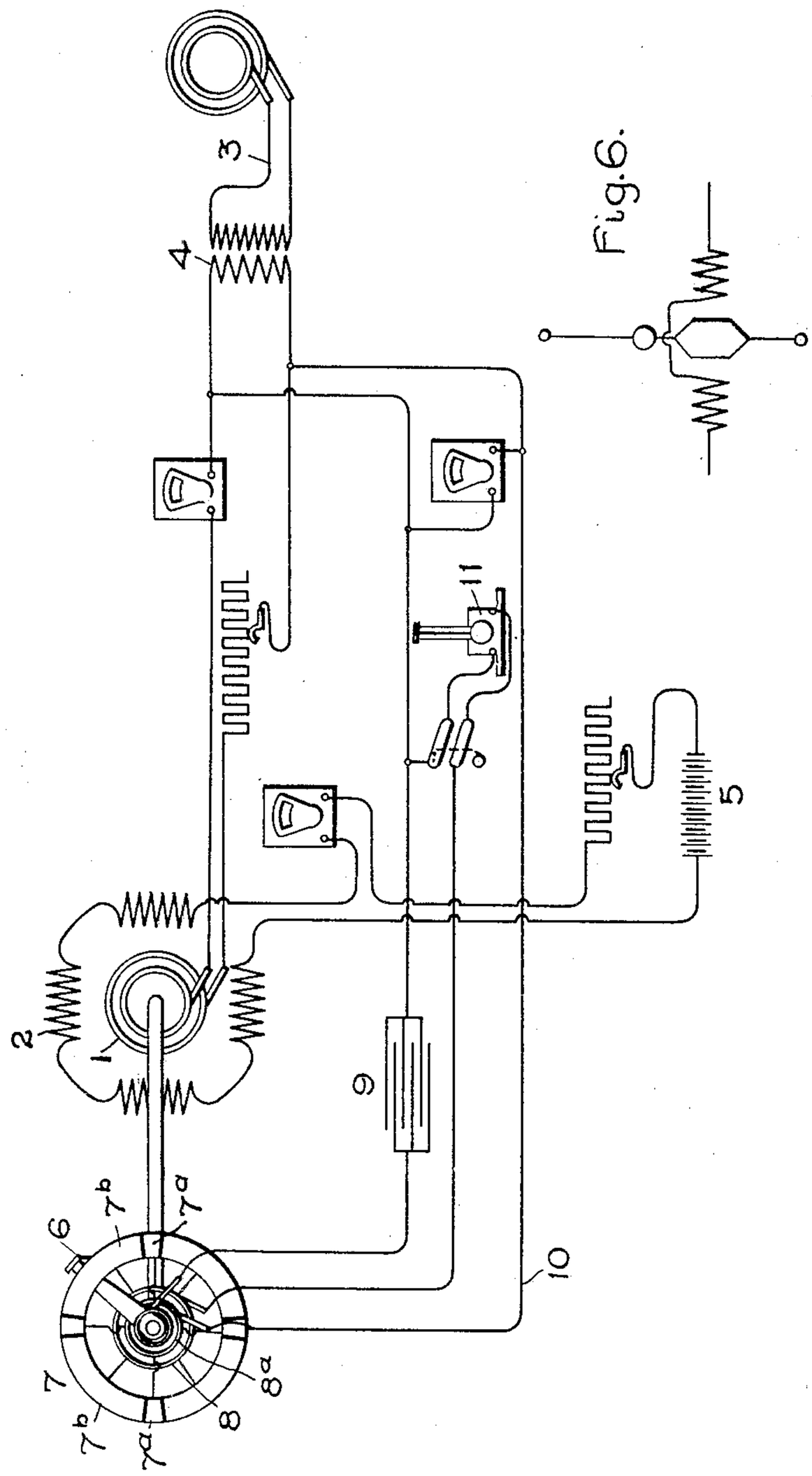

Fig.6.

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No. 768,953. Patented August 30, 1904.

UNITED STATES PATENT OFFICE.

LEWIS T. ROBINSON, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

RECORDING APPARATUS FOR ELECTRIC WAVES.

SPECIFICATION forming part of Letters Patent No. 768,953, dated August 30, 1904.

Application filed November 11, 1901. Serial No. 81,850. (No model.)

To all whom it may concern:

Be it known that I, LEWIS T. ROBINSON, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Recording Apparatus for Electric Waves, of which the following is a specification.

The object of this invention is to provide apparatus for facilitating the tracing or recording in permanent form of waves of electric energy or its components.

It has heretofore been the practice to secure instantaneous values of electromotive force of an alternating current at different parts of a period and then plot the wave by hand from readings rendered by a suitable indicating instrument. I have rendered this operation much less tedious and more accurate by providing means for automatically tracing the form of the wave. I prefer to accomplish this by photographic apparatus, the form of the wave in potential, current, or power being indicated by a separate instrument. This instrument comprises a synchronous motor driven from the circuit the form of whose wave is to be taken, a brush driven by the motor also electrically connected with such circuit, and a relatively rotatable device in cooperative relation to said brush provided with insulated contacts permitting the charge through the brush of a local circuit including a suitable measuring instrument.

The preferred measuring instrument comprises a coil influenced by the successive charges of potential or current or power whose wave form is to be taken and rigidly connected with a mirror forming part of the photographic apparatus, said coil being mounted in a magnetic field. Thus by moving the contact device the height of the wave at any point of its cycle may be indicated by the deflection of the mirror, and by slowly turning the contact device and simultaneously moving the sensitive surface on which the wave is to be photographically printed the form of the wave is automatically taken.

A further feature of the invention embodies means for recording on the surface on which the wave is traced intersecting lines, by which the height of the wave at any part of its cycle may be easily measured.

The distinctive feature of my invention is the ability to record the wave shape being taken at any desired speed without affecting the form of the wave. In devices of this character which have been proposed prior to my invention the recording-surface is moved at a rate of speed which has no fixed relation to the potential or current which is being plotted, and consequently the length of the wave is variable with respect to its ordinates. In my organization there is provided a means for delivering repeated impulses corresponding to the potential or current at different points of a cycle, and these impulses are caused to operate upon a recording beam of light or equivalent indicator, and the surface on which the record is made is so connected to the shifting point of cyclic contact that it has a coördinate movement therewith, so that if the apparatus is arrested at any point during the plotting operation there is simply impressed upon the recording-surface a longer continuance of the potential or current corresponding to that point.

My invention therefore comprises means for recording electrical waves comprising a synchronously-operating device for plotting the strength of the wave at any part of the cycle, a movable contact for varying the cyclic point being plotted, and means for coordinately and progressively recording these points of wave strength. It comprises also other features of novelty which will be hereinafter more fully described.

In the accompanying drawings, which illustrate the invention, Figure 1 is a perspective view of apparatus embodying my improvements. Figs. 2 and 3 are sectional details of the photographic apparatus. Fig. 4 is a perspective view of a slide for the photographic-plate holder. Fig. 5 is a diagram showing the circuit relations of the various parts of the apparatus, and Fig. 6 is a diagram of a recording device suitable for waves of power.

Referring first to the diagram, 1 represents the armature, and 2 the field-magnet circuit, of

a synchronous motor the armature of which is connected with the circuit 3 whose wave form is to be taken. It may be derived inductively from a transformer 4 or otherwise, as deemed most expedient. The field-magnet is furnished with direct current from a battery 5 or other suitable source of direct current. These circuits may include rheostats and voltmeters for determining and indicating the strength of current employed. The synchronous motor drives a contact-brush 6 around a relatively stationary disk 7, mounted so that it may be rotated through part of a revolution and carrying on its periphery a number of short and long contact-segments 7^a 7^b, the several sets being symmetrically distributed and connected in groups, so that all the long contacts form a single group, as do also all the short contacts, and current may be led to and from them by means of annular contact-rings 8 8^a. The brush 6 is connected with one side of the circuit whose wave form is to be taken and includes a condenser 9. The short insulated contact-segments 7^a connect with the other side of the circuit by a wire 10. Thus when the circuit connections are closed an intermittent series of electrical impulses are delivered to the condenser by means of the contact-segments 7^a and a similar series of discharges permitted through the long contact-segments 7^b and a mirror-galvanometer or other suitable recording instrument 11. These impulses are so rapid that the deflection is constant for any given angular position of the contact-disk 7, assuming, of course, that the shape of the wave being taken is constant. I prefer to employ as a recording device a mirror-galvanometer, the mirror being mounted in a photographic dark box, as indicated in Fig. 1 at 12, and coöperating with a lamp 13 in a closed chamber of the box mounted so as to throw a parallel beam of light through a lens 14 upon the mirror. This beam is thrown upon a photographic plate in a plate-holder 15, mounted to slide vertically between suitable guides and under the control of a cord 16, connected with a sector 17, forming part of the rotatable disk which delivers the energy to be measured.

It will be noted that there is a fixed relation between the disk, 7 by which the cyclic point of wave plotting is determined, and the photographic-plate holder, and by this means the recording-surface is moved always coördinately with the varying point of current or potential which is affecting the current-measuring instrument. The brush 6 delivers its repeated contact at any point throughout the range of motion of the short contacts 7^a of the disk. It is evident, therefore, that if the handle connected to the sector 17 is arrested at any point while the wave is being plotted no damage to the shape of the wave can result, since the point of cyclic engagement remains the same, and the height of the ordinate of the recording-surface is not altered unless the wave form or impulse of current should itself change. From this it results that there is no definitely-determined movement on the part of the operator required and the wave may be plotted fast or slowly with equal accuracy. This is equally desirable for photographic or mechanical recording, since it admits of moderate speeds and does not require extraordinarily-sensitive materials or instruments.

The plate-holder is provided with two slides, one of which is opaque and marked with transparent cross-lines, as indicated in Fig. 4, to permit transmission of light through the slide along these lines. This may be easily accomplished by forming the slide of transparent or translucent material, coating it with an apaque paint, and scratching cross-section lines, as indicated in Fig. 4. Both the ruled and the outer opaque slide are raised during the operation of taking the form of the wave, the sector 17 and disk 7 being shifted after the motor has been brought to synchronism. This latter may be easily accomplished by means of a hand-crank 18 and gearing adapted to be thrown into and out of clutch by means of the hand-operated lever 19. The motor is brought up to speed by means of the hand-crank, the speed being indicated by a suitable tachometer. The clutch is then operated and the motor permitted to run free and connection closed with the alternating circuit. The contact-disk 7 is then slowly shifted, during which the changing value of energy in the operating-coil of the reflecting-galvanometer traces the form of the wave on the photographic plate, which is given a movement of translation in a direction at right angles to the ordinates of the wave by means of the cord 16 and sector 17. The angle through which the disk 7 is shifted will obviously depend upon the number of poles in the synchronous motor, a complete wave being plotted by an angular movement equal to that subtended by lines passing through two consecutive poles of the same sign. After a complete wave or as much as is desired has been photographed by the required extent of angular movement of the disk 7 this is restored to its initial position and the ruled slide (shown in Fig. 4) closed. A lamp 20 within the box is then flashed, which prints the cross-lines upon the plate. The latter, with the photograph of the wave form and the impressed cross-lines, is then developed, and any distortion due to slipping or uneven shrinkage of the film during or after development of the plate affects the form of the wave and the measuring-lines alike.

The invention may be employed to take the form of potential, current, or power waves, and the instrument may be made single or in duplicate, so as to take potential and current at the same time, if desired. In taking the

latter the mirror may be subjected to the joint influence of two coil systems, one connected in potential and the other in current relation to the circuit whose wave form is to be taken, as indicated in Fig. 6. While I prefer to employ a condenser alternately charged and discharged, as described, my invention also includes the direct application of instantaneous potential to the recording instrument, the aggregate effect of a continuous series of charges being to develop a resultant deflection varying according to the potential imposed.

While I have herein described a photographic recording device as the preferred form, my invention is not limited to such a recorder in is broadest phase, as in lieu of a mirror may be employed a pointer carrying a recording-stylus in contact with a traveling record-sheet. An instrument of the latter kind, however, requires a much greater torque and is not so economical of energy. It is not, moreover, essential that a complete wave be plotted by the movement of the contact-disk, as a shorter range of movement will of course give a part of a wave, which may for some purposes be satisfactory.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. Apparatus for recording electric-wave forms, comprising a recording device, a contact driven in synchronism with the period of the wave, and means for repeatedly connecting the alternating circuit through the contact with the recording device at different points of a cycle and connections for shifting the recording-surface coördinately with the shifting point of the repeated contact progressively through a required part of a cycle of the current.

2. Apparatus for recording electric-wave forms, comprising a contact device, means for moving it synchronously with the period of the wave, a recording device connecting with the alternating-current circuit through an adjustable coöperating contact, and means for shifting the adjustable contact coördinately with the recording-surface through an angular range corresponding to a required part of a wave period.

3. Apparatus for recording electric-wave forms, comprising a synchronous motor, a starting device therefor, a contact-trailer and contact-segments operated for relative movement by the motor, an indicator charged with a succession of instantaneous wave values for each part of a cycle, an operating device for varying the time of engagement of the trailer and segments with relation to the wave period, and a recording-surface moved by the same operating device.

4. Apparatus for recording electric-wave forms, comprising a synchronous motor driven by the same source as the current whose wave form is to be measured, a local circuit containing an electrostatic capacity and an indicating instrument, a contact device for delivering an instantaneous value of any phase of a wave, means for shifting a coöperating contact through a definite range of movement, and a transversely-movable recording-surface having a rate of travel fixed with relation to the movement of the contact.

5. Apparatus for recording electric-wave forms, comprising a synchronous motor driven by the same source as the current whose wave form is desired, an adjustable contact having two groups of insulated segments, a brush electrically connected with the alternating circuit in relative movement to said segments and so maintained by the motor, a condenser and mirror-galvanometer in a circuit adapted to be rapidly charged and discharged by the movement, a photographic recording-surface movable transversely to the vibration of the reflected beam and connections for maintaining coördinate movement of the contact and recording-surface.

6. Recording apparatus for electric-wave forms, comprising a synchronously-driven contact device, a movable device for progressively connecting the same at different points of a cycle in alternate relation to the current whose wave form is to be traced and to a discharge-circuit, a recording instrument controlled by such discharge-circuit and coördinately movable with the progressive movable cyclic device.

7. Recording apparatus for electric-wave forms, consisting in a synchronously-operated contact device driven by the same source as the current whose wave form is to be taken, a condenser progressively and intermittently charged and discharged by such contact device, a recording device controlled by the discharge-circuit, and connections for shifting the recording-surface coördinately with the progressive point of charge and discharge.

8. Apparatus for recording electric-wave forms, comprising a synchronously-operated contact device driven by the same source as the current whose wave form is to be taken, a condenser periodically charged thereby, a discharge-circuit for the condenser including an indicator, and means for moving a recording-surface in a direction transverse to the deflection of the indicator simultaneously and coördinately with the movement of the contact-surface on which the contact bears.

9. In an apparatus for recording rapidly-fluctuating values, the combination of a photographic film, means for tracing the varying value thereon, and means for superposing on the same film a series of cross-section lines parallel to the axes of ordinates and abscissæ.

In witness whereof I have hereunto set my hand this 9th day of November, 1901.

LEWIS T. ROBINSON.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.